OVERVIEW

UML (Unified Modeling Language) is a standard language for specifying, visualizing, constructing, and documenting the artifacts of software systems. UML was created by the Object Management Group (OMG) and UML 1.0 specification draft was proposed to the OMG in January 1997. It was initially started to capture the behavior of complex software and non-software system and now it has become an OMG standard. UML is not a programming language but tools can be used to generate code in various languages using UML diagrams. UML has a direct relation with object oriented analysis and design.

PURPOSE OF UML

There are a number of goals for developing UML but the most important is to define some general-purpose modeling language, which all modelers can use and it also needs to be made simple to understand and use.

UML diagrams are not only made for developers but also for business users, common people, and anybody interested to understand the system. The system can be a software or non-software system. Thus it must be clear that UML is not a development method rather it accompanies with processes to make it a successful system.

In conclusion, the goal of UML can be defined as a simple modeling mechanism to model all possible practical systems in today's complex environment.

ROLE OF UML IN OO DESIGN

Most of the UML diagrams discussed so far are used to model different aspects such as static, dynamic, etc. Now whatever be the aspect, the artifacts are nothing but objects. If we look into class diagram, object diagram, collaboration diagram, interaction diagrams all would basically be designed based on the objects.
Hence, the relation between OO design and UML is very important to understand. The OO design is transformed into UML diagrams according to the requirement. Before understanding the UML in detail, the OO concept should be learned properly. Once the OO analysis and design is done, the next step is very easy. The input from OO analysis and design is the input to UML diagrams.

UML BLOCKS

As UML describes the real-time systems, it is very important to make a conceptual model and then proceed gradually. The conceptual model of UML can be mastered by learning the following three major elements −

- UML building blocks
- Rules to connect the building blocks
- Common mechanisms of UML

The building blocks of UML can be defined as −

- Things
- Relationships
- Diagrams

Things

Things are the most important building blocks of UML. Things can be −

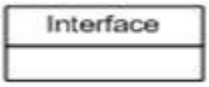
- Structural
- Behavioral
- Grouping
- Notational

Structural Things

Structural things define the static part of the model. They represent the physical and conceptual elements. Following are the brief descriptions of the structural things.

Class − Class represents a set of objects having similar responsibilities.

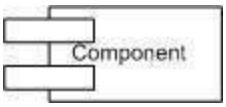
Interface − Interface defines a set of operations, which specify the responsibility of a class.



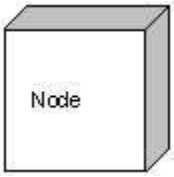
Collaboration −Collaboration defines an interaction between elements.

Use case −Use case represents a set of actions performed by a system for a specific goal.

Component −Component describes the physical part of a system.



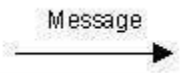
Node − A node can be defined as a physical element that exists at run time.



Behavioral Things

A behavioral thing consists of the dynamic parts of UML models. Following are the behavioral things −

Interaction − Interaction is defined as a behavior that consists of a group of messages exchanged among elements to accomplish a specific task.



State machine − State machine is useful when the state of an object in its life cycle is important. It defines the sequence of states an object goes through in response to events. Events are external factors responsible for state change

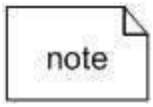
Grouping Things

Grouping things can be defined as a mechanism to group elements of a UML model together. There is only one grouping thing available −

Package − Package is the only one grouping thing available for gathering structural and behavioral things.

Notational Things

Notational things can be defined as a mechanism to capture remarks, descriptions, and comments of UML model elements. Note - It is the only one notational thing available. A note is used to render comments, constraints, etc. of an UML element.

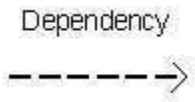


Relationships

Relationship is another most important building block of UML. It shows how the elements are associated with each other and this association describes the functionality of an application. A model is not complete unless the relationships between elements are described properly. The *Relationship* gives a proper meaning to a UML model. Following are the different types of relationships available in UML.

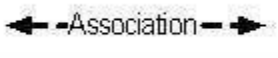
Dependency

Dependency is a relationship between two things in which change in one element also affects the other.



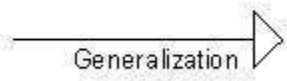
Association

Association is basically a set of links that connects the elements of a UML model. It also describes how many objects are taking part in that relationship.



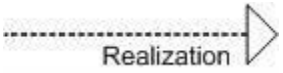
Generalization

Generalization can be defined as a relationship which connects a specialized element with a generalized element. It basically describes the inheritance relationship in the world of objects.



Realization

Realization can be defined as a relationship in which two elements are connected. One element describes some responsibility, which is not implemented and the other one implements them. This relationship exists in case of interfaces.



UML Diagrams

UML diagrams are the ultimate output of the entire discussion. All the elements, relationships are used to make a complete UML diagram and the diagram represents a system. The visual effect of the UML diagram is the most important part of the entire process. All the other elements are used to make it complete
UML includes the following nine diagrams:

- Class diagram
- Object diagram
- Use case diagram
- Sequence diagram
- Collaboration diagram
- Activity diagram
- State chart diagram
- Deployment diagram
- Component diagram

UML - Class Diagram

Class diagram is a static diagram. It represents the static view of an application. Class diagram is not only used for visualizing, describing, and documenting different aspects of a system but also for constructing executable code of the software application.

Class diagram describes the attributes and operations of a class and also the constraints imposed on the system. The class diagrams are widely used in the modeling of object-oriented systems because they are the only UML diagrams, which can be mapped directly with object-oriented languages.

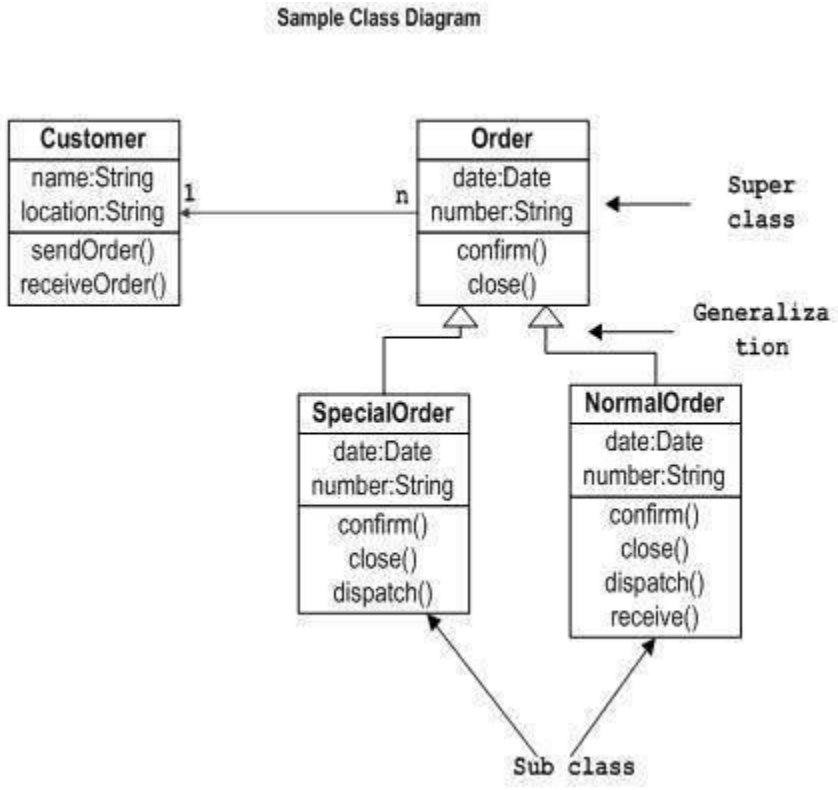
Class diagram shows a collection of classes, interfaces, associations, collaborations, and constraints. It is also known as a structural diagram.

The purpose of the class diagram can be summarized as −

- Analysis and design of the static view of an application.
- Describe responsibilities of a system.

- Base for component and deployment diagrams.
- Forward and reverse engineering.

The following class diagram has been drawn considering all the points mentioned above.



UML - Object Diagrams

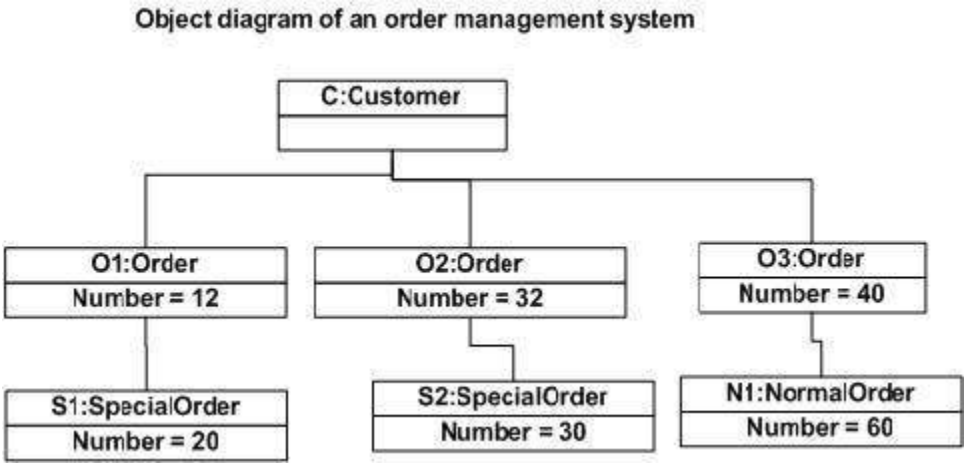
Object diagrams are derived from class diagrams so object diagrams are dependent upon class diagrams.

Object diagrams represent an instance of a class diagram. The basic concepts are similar for class diagrams and object diagrams. Object diagrams also represent the static view of a system but this static view is a snapshot of the system at a particular moment.

The purpose of the object diagram can be summarized as −

- Forward and reverse engineering.
- Object relationships of a system
- Static view of an interaction.

- Understand object behavior and their relationship from practical perspective.



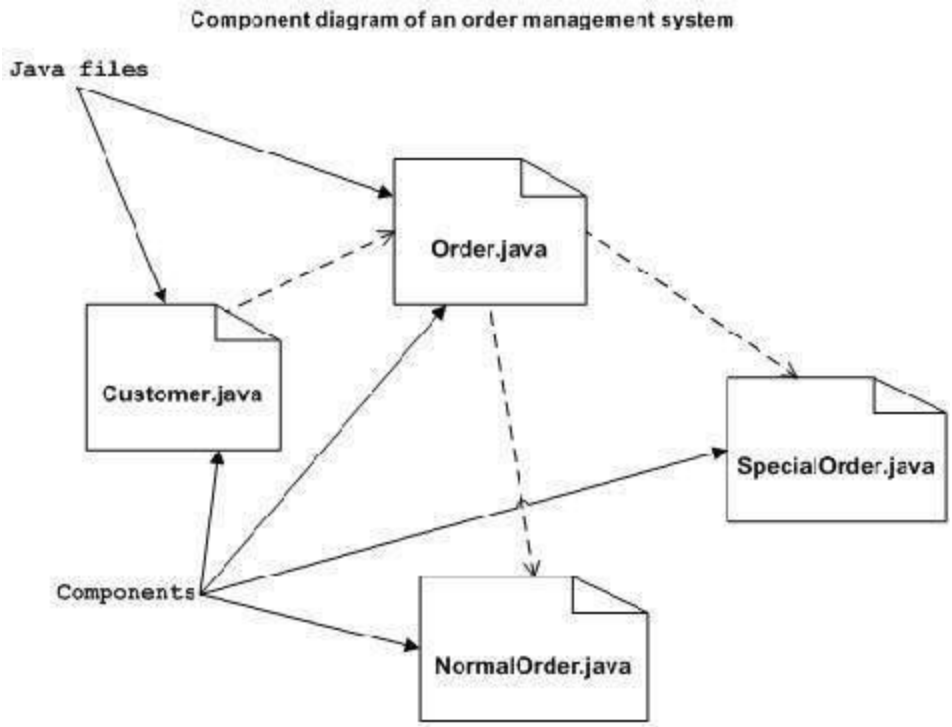
UML - Component Diagrams

Component diagrams are different in terms of nature and behavior. Component diagrams are used to model the physical aspects of a system. Now the question is, what are these physical aspects? Physical aspects are the elements such as executables, libraries, files, documents, etc. which reside in a node.

Component diagrams are used to visualize the organization and relationships among components in a system. These diagrams are also used to make executable systems.

The purpose of the component diagram can be summarized as −

- Visualize the components of a system.
- Construct executables by using forward and reverse engineering.
- Describe the organization and relationships of the components.



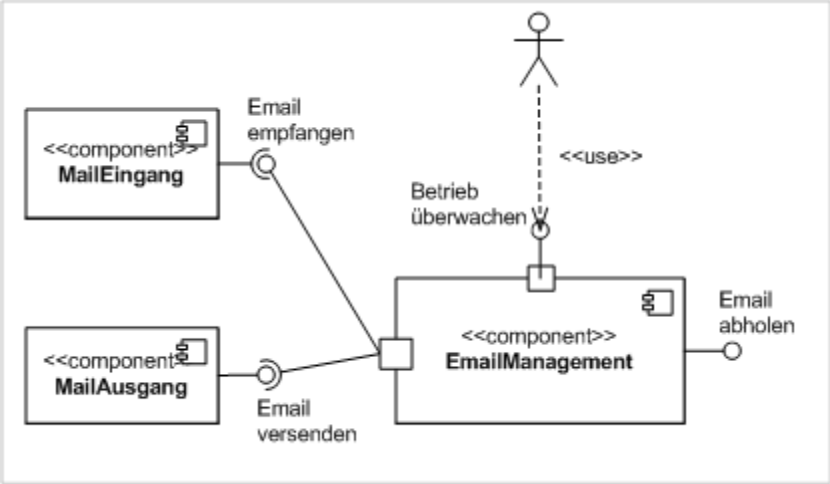
UML - Deployment Diagrams

Deployment diagrams are used to visualize the topology of the physical components of a system, where the software components are deployed.

Deployment diagrams are used to describe the static deployment view of a system. Deployment diagrams consist of nodes and their relationships.

The purpose of deployment diagrams can be described as −

- Visualize the hardware topology of a system.
- Describe the hardware components used to deploy software components.
- Describe the runtime processing nodes.



UML - Use Case Diagrams

To model a system, the most important aspect is to capture the dynamic behavior. Dynamic behavior means the behavior of the system when it is running/operating.

Only static behavior is not sufficient to model a system rather dynamic behavior is more important than static behavior. In UML, there are five diagrams available to model the dynamic nature and use case diagram is one of them. Now as we have to discuss that the use case diagram is dynamic in nature, there should be some internal or external factors for making the interaction.

These internal and external agents are known as actors. Use case diagrams consists of actors, use cases and their relationships. The diagram is used to model the system/subsystem of an application. A single use case diagram captures a particular functionality of a system.

the purposes of use case diagrams can be said to be as follows −

- Used to gather the requirements of a system.
- Used to get an outside view of a system.
- Identify the external and internal factors influencing the system.
- Show the interaction among the requirements are actors.

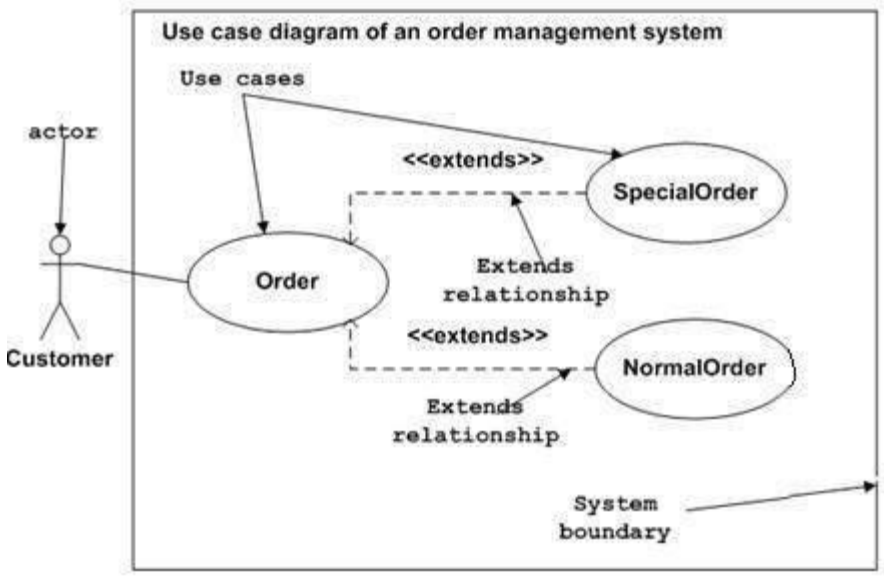


Figure: Sample Use Case diagram

UML - Interaction Diagrams

This interaction is a part of dynamic behavior of the system. This interactive behavior is represented in UML by two diagrams known as Sequence diagram and Collaboration diagram. The basic purpose of both the diagrams are similar.

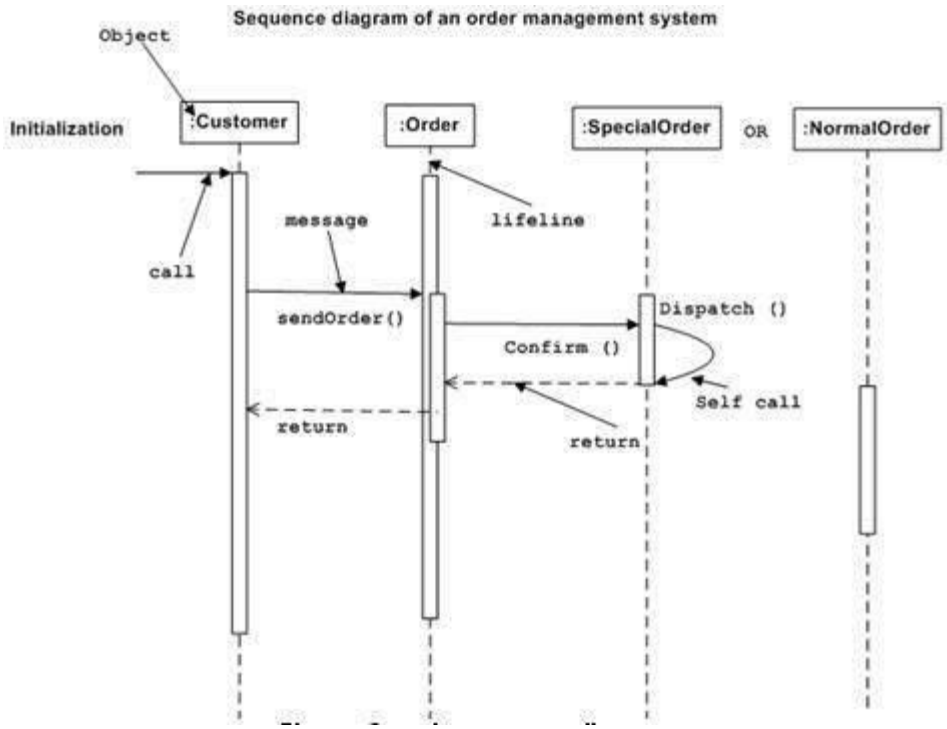
Sequence diagram emphasizes on time sequence of messages and collaboration diagram emphasizes on the structural organization of the objects that send and receive messages.

The purpose of interaction diagram is −

- To capture the dynamic behavior of a system.
- To describe the message flow in the system.
- To describe the structural organization of the objects.
- To describe the interaction among objects.

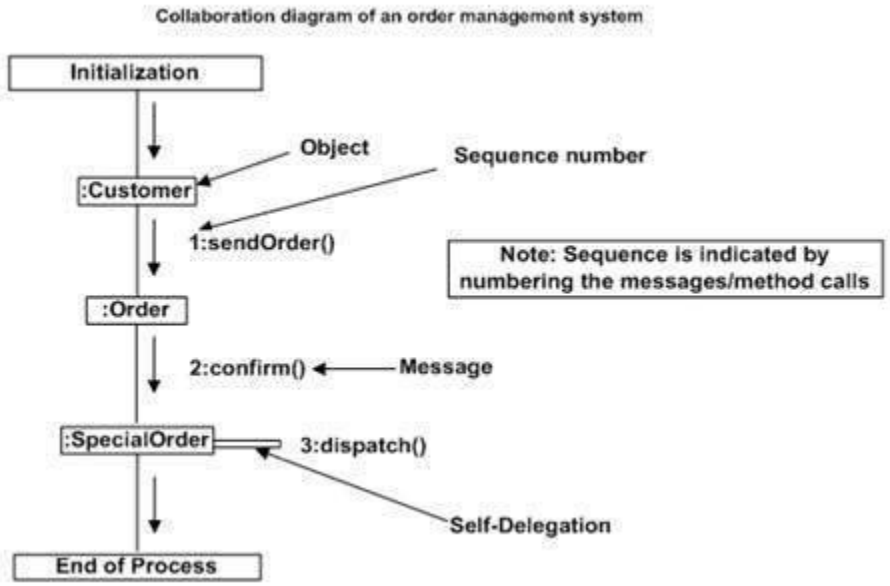
Following are two interaction diagrams modeling. The first diagram is a sequence diagram and the second is a collaboration diagram

The Sequence Diagram



The Collaboration Diagram

The second interaction diagram is the collaboration diagram. It shows the object organization as seen in the following diagram. In the collaboration diagram, the method call sequence is indicated by some numbering technique. The number indicates how the methods are called one after another. We have taken the same order management system to describe the collaboration diagram.

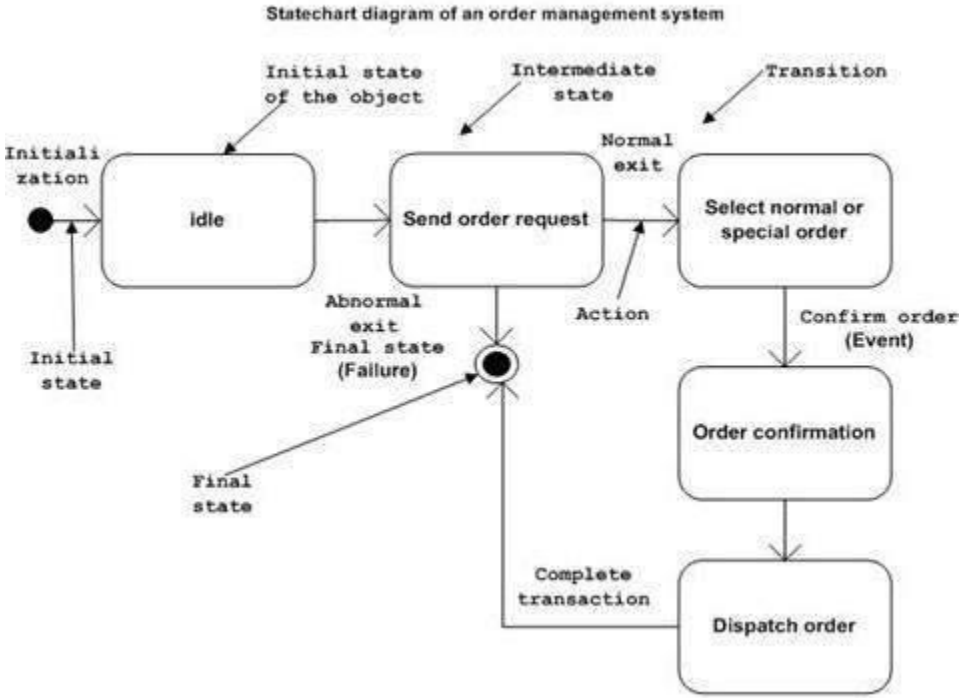


UML - State chart Diagrams

The name of the diagram itself clarifies the purpose of the diagram and other details. It describes different states of a component in a system. The states are specific to a component/object of a system. A state chart diagram describes a state machine. State machine can be defined as a machine which defines different states of an object and these states are controlled by external or internal events.

Following are the main purposes of using state chart diagrams −

- To model the dynamic aspect of a system.
- To model the lifetime of a reactive system.
- To describe different states of an object during its life time.
- Define a state machine to model the states of an object



UML - Activity Diagrams

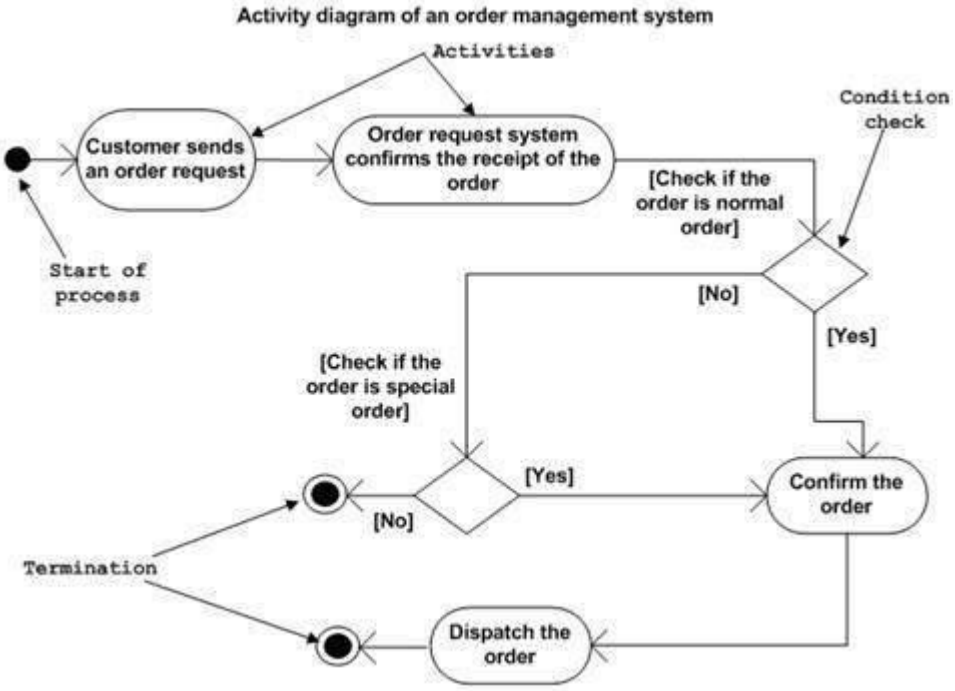
Activity diagram is another important diagram in UML to describe the dynamic aspects of the system.

Activity diagram is basically a flowchart to represent the flow from one activity to another activity. The activity can be described as an operation of the system.

The control flow is drawn from one operation to another. This flow can be sequential, branched, or concurrent. Activity diagrams deal with all type of flow control by using different elements such as fork, join, etc.

The purpose of an activity diagram can be described as −

- Draw the activity flow of a system.
- Describe the sequence from one activity to another.
- Describe the parallel, branched and concurrent flow of the system.



UML- Architecture

Any real-world system is used by different users. The users can be developers, testers, business people, analysts, and many more. Hence, before designing a system, the architecture is made with different perspectives in mind. The most important part is to visualize the system from the perspective of different viewers. The better we understand the better we can build the system.

UML plays an important role in defining different perspectives of a system. These perspectives are −

- Design
- Implementation
- Process
- Deployment

The center is the Use Case view which connects all these four. A Use Case represents the functionality of the system. Hence, other perspectives are connected with use case.

Design of a system consists of classes, interfaces, and collaboration. UML provides class diagram, object diagram to support this.

Implementation defines the components assembled together to make a complete physical system. UML component diagram is used to support the implementation perspective.

Process defines the flow of the system. Hence, the same elements as used in Design are also used to support this perspective.

Deployment represents the physical nodes of the system that forms the hardware. UML deployment diagram is used to support this perspective.

UML - Modeling Types

It is very important to distinguish between the UML model. Different diagrams are used for different types of UML modeling. There are three important types of UML modeling.

Structural Modeling

Structural modeling captures the static features of a system. They consist of the following −

- Classes diagrams
- Objects diagrams
- Deployment diagrams
- Package diagrams
- Composite structure diagram
- Component diagram

Structural model represents the framework for the system and this framework is the place where all other components exist. Hence, the class diagram, component diagram and deployment diagrams are part of structural modeling. They all represent the elements and the mechanism to assemble them.

The structural model never describes the dynamic behavior of the system. Class diagram is the most widely used structural diagram.

Behavioral Modeling

Behavioral model describes the interaction in the system. It represents the interaction among the structural diagrams. Behavioral modeling shows the dynamic nature of the system. They consist of the following −

- Activity diagrams
- Interaction diagrams
- Use case diagrams

All the above show the dynamic sequence of flow in a system.

Architectural Modeling

Architectural model represents the overall framework of the system. It contains both structural and behavioral elements of the system. Architectural model can be defined as the blueprint of the entire system. Package diagram comes under architectural modeling.

UML BASIC NOTATIONS

UML is popular for its diagrammatic notations. We all know that UML is for visualizing, specifying, constructing and documenting the components of software and non-software systems. Hence, visualization is the most important part which needs to be understood and remembered.

UML notations are the most important elements in modeling. Efficient and appropriate use of notations is very important for making a complete and meaningful model. The model is useless, unless its purpose is depicted properly.

Hence, learning notations should be emphasized from the very beginning. Different notations are available for things and relationships. UML diagrams are made using the notations of things and relationships. Extensibility is another important feature which makes UML more powerful and flexible.

Structural Things

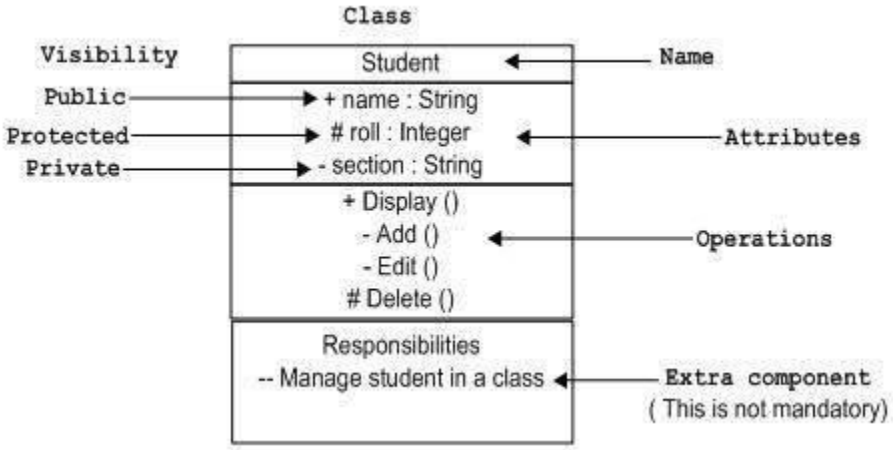
Graphical notations used in structural things are most widely used in UML. These are considered as the nouns of UML models. Following are the list of structural things.

- Classes
- Object
- Interface
- Collaboration
- Use case
- Active classes
- Components
- Nodes

Class Notation

UML *class* is represented by the following figure. The diagram is divided into four parts.

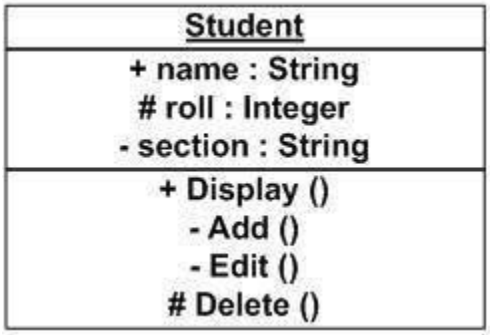
- The top section is used to name the class.
- The second one is used to show the attributes of the class.
- The third section is used to describe the operations performed by the class.
- The fourth section is optional to show any additional components.



Classes are used to represent objects. Objects can be anything having properties and responsibility.

Object Notation

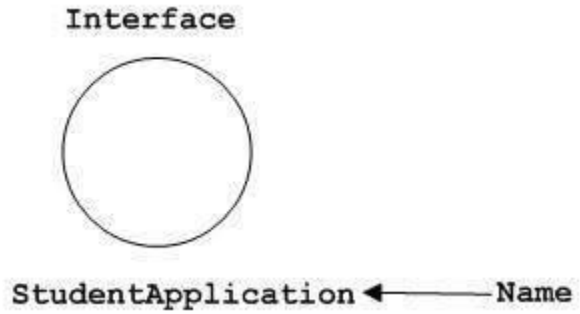
The *object* is represented in the same way as the class. The only difference is the *name* which is underlined as shown in the following figure.



As the object is an actual implementation of a class, which is known as the instance of a class. Hence, it has the same usage as the class.

Interface Notation

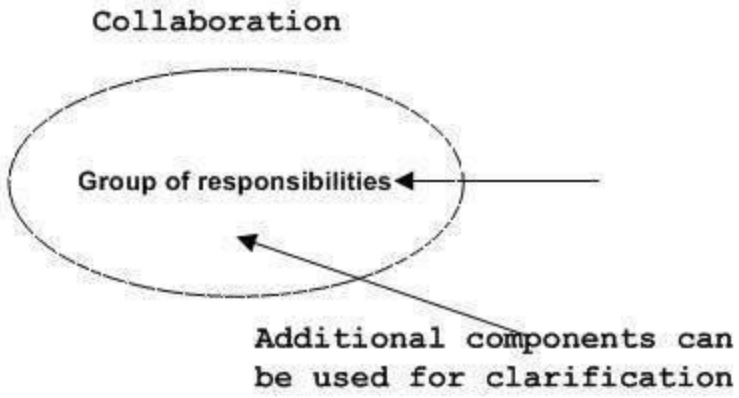
Interface is represented by a circle as shown in the following figure. It has a name which is generally written below the circle.



Interface is used to describe the functionality without implementation. Interface is just like a template where you define different functions, not the implementation. When a class implements the interface, it also implements the functionality as per requirement.

Collaboration Notation

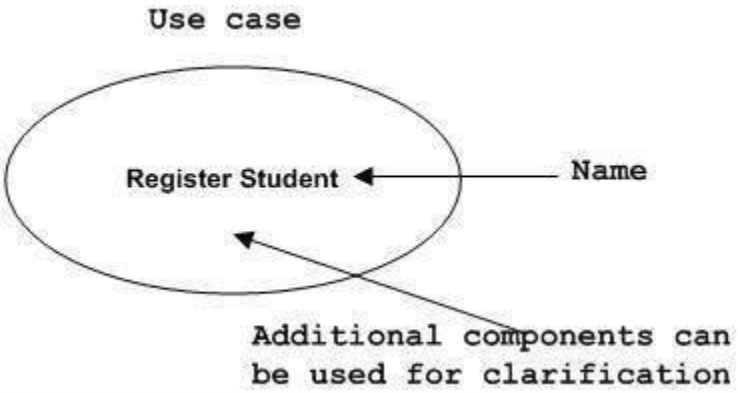
Collaboration is represented by a dotted eclipse as shown in the following figure. It has a name written inside the eclipse.



Collaboration represents responsibilities. Generally, responsibilities are in a group.

Use Case Notation

Use case is represented as an eclipse with a name inside it. It may contain additional responsibilities.



Use case is used to capture high level functionalities of a system.

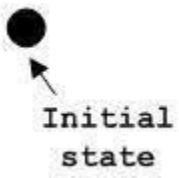
Actor Notation

An actor can be defined as some internal or external entity that interacts with the system.

An actor is used in a use case diagram to describe the internal or external entities.

Initial State Notation

Initial state is defined to show the start of a process. This notation is used in almost all diagrams.



The usage of Initial State Notation is to show the starting point of a process.

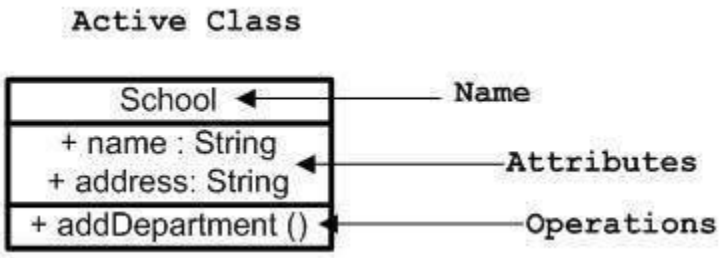
Final State Notation

Final state is used to show the end of a process. This notation is also used in almost all diagrams to describe the end.

The usage of Final State Notation is to show the termination point of a process.

Active Class Notation

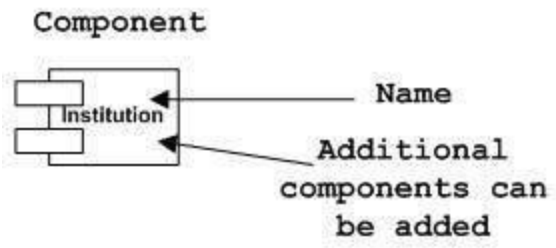
Active class looks similar to a class with a solid border. Active class is generally used to describe the concurrent behavior of a system.



Active class is used to represent the concurrency in a system.

Component Notation

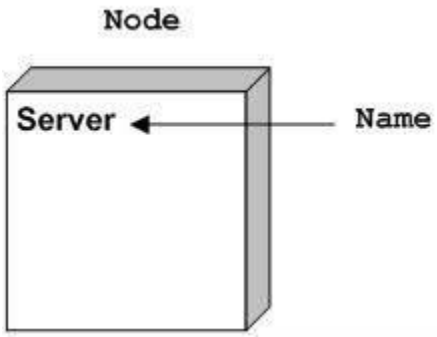
A component in UML is shown in the following figure with a name inside. Additional elements can be added wherever required.



Component is used to represent any part of a system for which UML diagrams are made.

Node Notation

A node in UML is represented by a square box as shown in the following figure with a name. A node represents the physical component of the system.



Node is used to represent the physical part of a system such as the server, network, etc.

Behavioral Things

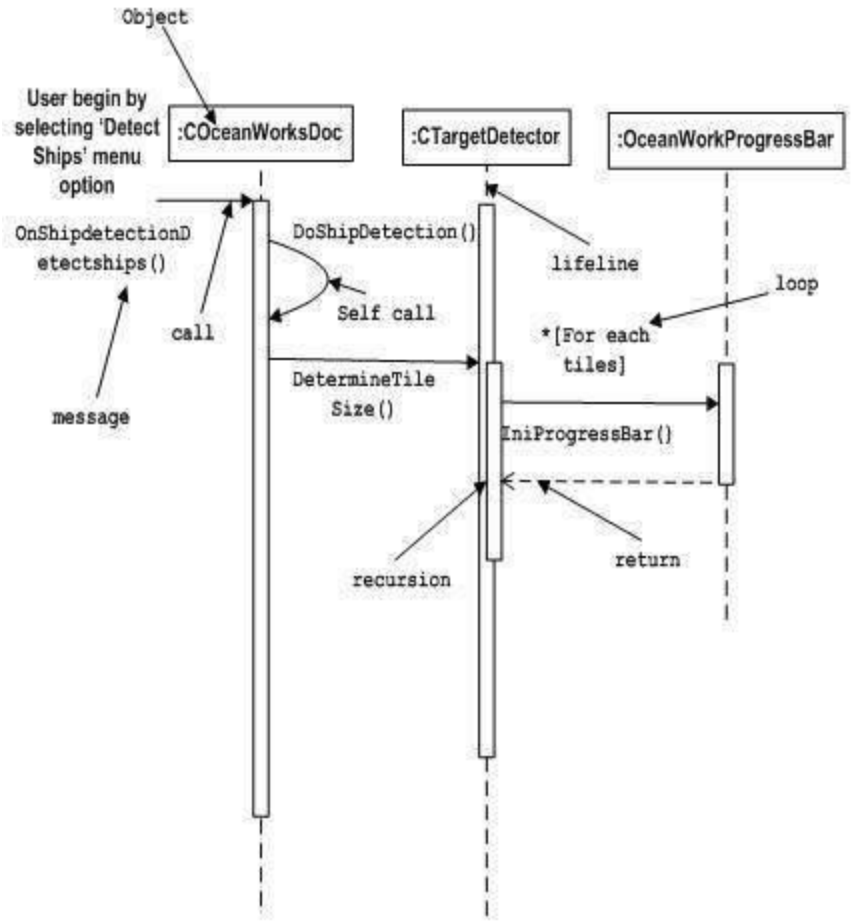
Dynamic parts are one of the most important elements in UML. UML has a set of powerful features to represent the dynamic part of software and non-software systems. These features include *interactions* and *state machines*.

Interactions can be of two types −

- Sequential (Represented by sequence diagram)
- Collaborative (Represented by collaboration diagram)

Interaction Notation

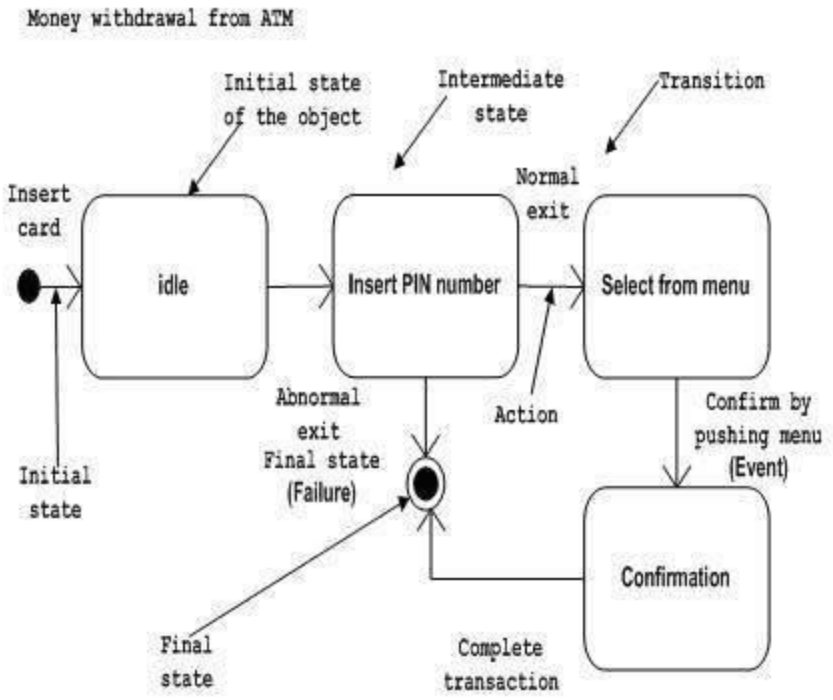
Interaction is basically a message exchange between two UML components. The following diagram represents different notations used in an interaction.



Interaction is used to represent the communication among the components of a system.

State Machine Notation

State machine describes the different states of a component in its life cycle. The notations are described in the following diagram.



State machine is used to describe different states of a system component. The state can be active, idle, or any other depending upon the situation.

Grouping Things

Organizing the UML models is one of the most important aspects of the design. In UML, there is only one element available for grouping and that is package.

Package Notation

Package notation is shown in the following figure and is used to wrap the components of a system.